ANGLER HARVEST SURVEY

BENNETT LAKE 2009

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Key Findings

- Anglers spent 1,020 hours angling on Bennett Lake in the summer of 2009. This is 0.11 hours angling / ha over the summer, a low level even for a large Yukon lake.

- Angler success, as measured by the number of lake trout caught per hour of angling rose from 0.08 in 1990 to 0.13 in 2009, an average value for Yukon fisheries.

- Anglers caught 128 lake trout and released 40%. Including a 15% rate of incidental mortality (death) from catch and release, the total estimated harvest was 116 kg of lake trout.

- For such a large lake, Bennett has very low productivity (Optimal Sustainable Yield of about 535 kg). When angler harvest is combined with other sources, including the commercial fishery, total harvest is near sustainable limits and there are other un-quantified harvests.

- Future efforts should be directed at a full accounting of all harvests (including subsistence) and improving the understanding of lake trout movements through connected water bodies in the Southern Lakes.

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Introduction

We conduct angler harvest surveys, also called creel surveys, on a number of Yukon recreational fisheries each year. We use these surveys, together with other fish and fishery-related assessments, to find out if the harvest of fish from the lake is sustainable. Environment Yukon's goal is to conduct angler harvest surveys on key fisheries either every 5 years or according to angler patterns and management concerns. The results of the surveys directly contribute to management decisions that make sure fisheries are sustainable over the long term.

Bennett Lake is located in southwest Yukon within the traditional territory of the Carcross/Tagish First Nation. It is a large, deep lake with an area of 9,680 ha (96.80 km^2) and a mean depth of 61.9 m. Bennett Lake extends from Carcross, Yukon, into northern British Columbia. Bennett is at the heart of the Southern Lakes system which makes up the headwaters of the Yukon River. Bennett, Nares, Tagish, Marsh, and Atlin lakes are all closely connected by large rivers that allow fish to readily migrate between water bodies. Bennett Lake is infamous for high winds and rough water making it inaccessible for many boaters. Bennett Lake is a Yukon-BC transboundary water; Yukon and BC angling licences are both valid on all parts of the lake.

Bennett Lake is an important fishery for the Carcross Tagish First Nation. Bennett Lake has been identified in the Carcross Tagish First Nation Final Agreement as being of special importance in terms of harvesting rights for freshwater fish. Subsistence fishing occurs in the spring and fall for cisco as well as other times of the year for lake trout and whitefish. No harvest records of the subsistence fishery are available.

Bennett Lake was designated for commercial fishing in 1961 but records indicate that there was a commercial fishery as far back as the Klondike Gold Rush of 1898. The gold rush trail from Skagway to Dawson used Bennett Lake to ferry goods and people on their journey north. Though commercial fishing has decreased in recent years there is still one active licence on the lake with a yearly quota of 550 kilograms of lake trout.

This is the second angler harvest survey we have conducted on Bennett Lake. The first was in 1990. Due to its local importance, current harvest pressures, and time lapsed since the previous harvest survey, Bennett Lake was identified as a priority for assessment in 2009.

The 2009 survey was done to:

- determine how much time anglers spent fishing (effort);
- understand the characteristics of the fishery and patterns of use;
- measure success rate of anglers;
- measure the level of harvest in relation to the productive capacity of the lake;
- record biological information on harvested fish;

- provide anglers with information about regulations; and
- establish a fisheries management presence.

Harvest Regulations

Bennett Lake has been managed as a Conservation Water (previously known as High Quality Water) since 2004 and as a Special Management Water from 2001 to 2004. These regulations protect larger fish and encourage the harvest of smaller fish, while allowing the retention of a trophy fish if caught. Barbless hooks are required. The lake trout catch limit is 2 fish per day with 2 fish in possession. All lake trout between 65 cm and 100 cm must be released, and only one lake trout in possession may be larger than 100 cm. The Arctic grayling catch limit is 4 fish per day with 4 fish in possession. All Arctic grayling between 40 cm and 48 cm must be released, and only one Arctic grayling in possession may be larger than 48 cm. The northern pike catch limit is 4 fish per day with 4 fish in possession. All northern pike between 75 cm and 105 cm must be released, and only one northern pike in possession may be larger than 105 cm. General catch and possession limits apply to all other species.

The regulation history for Bennett Lake is detailed in Appendix 1.

Methods

Survey

In 1990 the Yukon Government adopted survey methodology developed by the Ontario Ministry of Natural Resources (Lester and Trippel 1985). A field worker conducts face-to-face interviews with anglers on selected sample days throughout the summer. The worker asks a standard set of questions about the social and biological aspects of the fishery. Data gathered include:

- How much time did anglers spend fishing?
- What fishing methods did anglers use?
- How did anglers fish (boat, shore, etc.)?
- Were anglers guided?
- Where were anglers from?
- What type of visitor were anglers (day users, campers, etc.)?
- What kinds of fish were anglers trying to catch?
- How many fish did anglers catch?
- How many fish did anglers release?

Any other information offered by anglers about their fishing experience is also recorded.

The field worker also collects biological data on the catch of cooperative anglers. Biological data gathered include: length (mm), mass (g), sex, maturity,

an aging structure, as well as the collection of stomachs for content analysis in the lab. Any other information about general health and condition of the fish is recorded by the field worker (e.g., abnormalities, disease, lesions).

The field worker subjectively assesses the weather's effect on fishing over the entire sample day (no possible adverse effect, possible adverse effect, definite adverse effect).

The timing of the survey depends on management objectives, key species, and the nature of the fishery. It typically runs from ice out in the spring until either just after Labour Day or the end of September. The goal is to sample at least 20% of the total survey days. The survey is subdivided into several seasonal periods (usually 3 or 4) to better understand changes in angler activity. These periods are further divided into weekends and weekdays. Sample days are allocated to each period while considering both a higher weighting for those periods with the higher projected angler use and a minimum number of samples for each period.

Sample days are 14 hours long, 8:00AM to 10:00PM. On sample days, the field worker interviews all willing anglers. The field worker also records anglers who are observed but not interviewed.

Analysis

When the survey is finished, the data are entered into an Access database and analyzed using standard statistical methods. The age of sampled fish is determined by counting growth rings on the otolith (a small bone from the fish's head). Diet is determined by examining the stomach contents.

Lake Productivity

The productivity of a lake determines the amount of fish produced annually and can guide how much harvest can be sustained. Estimates of lake productivity are calculated using average lake depth, the concentration of total dissolved solids, and the average annual air temperature at the lake. Ryder's morphoedaphic index (1974) is used and incorporated into Schlesinger and Regier's equation (1982) for calculation of maximum sustained yield (MSY) for all species. Calculation of MSY for lake trout assumes a biomass of 30% lake trout; where appropriate this may be replaced by the most recent survey data. Following O'Connor (1982) and others, 15% of MSY provides an "optimum" sustained yield (OSY), which maintains high quality fisheries on light to moderately fished lakes.

2009 Bennett Lake Survey

The survey began May 15 and concluded September 9, 2009.

We used an access survey, meaning the field worker was stationed at the Carcross footbridge and boat launch at the north east end of the lake (Figure 1)

for the entire sample day and interviewed angling parties at the end of their fishing trip.

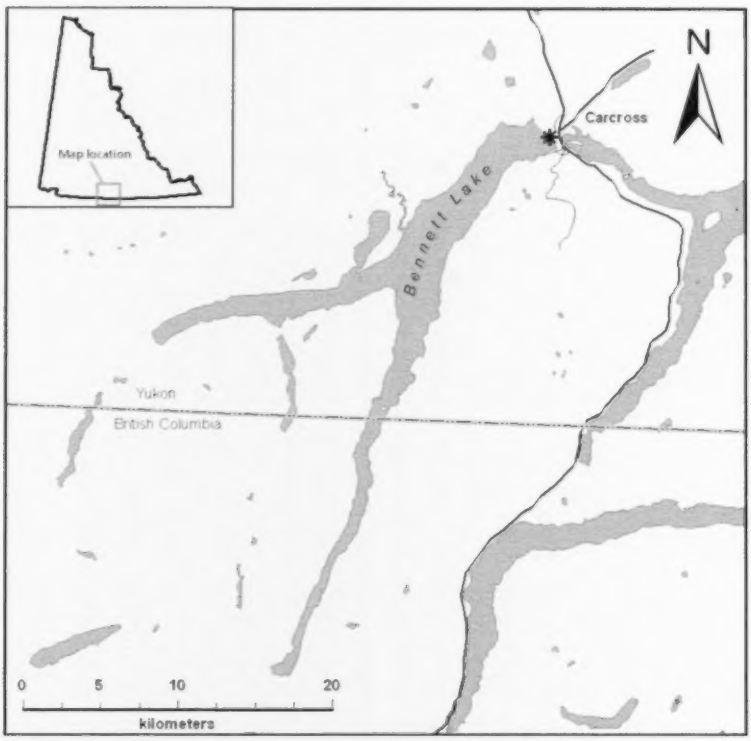

Figure 1. Bennett Lake, location of 2009 angler harvest survey (*).

The survey period was partitioned into 6 time periods, weekends and weekdays in May/June, July and August/September. Of the 118 day survey period, 37 days were sampled for an overall sampling effort of 31%.

We analyzed the data in 2 ways. In the first, we combined data across all 6 time periods, and in the second part we compared results between time periods. We analyzed all data at the party level.

Results of the 2009 Survey

Effort

Anglers spent 1,020 hours fishing on Bennett Lake over the 2009 survey period which is 0.10 hours per hectare, a below average effort for large lakes. There were a total of 267 anglers in 112 parties. On average, there was 8.6 hours of angler effort per day over the entire survey, and each angler fished for 3.8 hours.

Fishing Methods

Trolling was the most popular method of fishing, followed by a combination of methods and still fishing (Table 1). A few anglers fished by spin casting.

Table 1. Fishing methods, Bennett Lake, 2009.

Method of Fishing	Percent of Parties
Still	19%
Jig	
Drift	
Troll	50%
Spin Cast	6%
Fly Cast	
Other or Combination	25%

Methods of Access

The majority of anglers accessed the lake by motorboats (Table 2). Canoes were the only other method used.

Table 2. Angler access methods Bennett Lake, 2009.

Access Method	Percent of Parties
Canoe	6%
Rowboat	
Motorboat	94%
Shore	
Other	

Guided Anglers

No guided anglers were observed on Bennett Lake in 2009.

Angler Origin

Whitehorse anglers were the most frequent fishers, followed closely by local anglers (Table 3). The local angler category only includes residents of Carcross.

Table 3. Angler origin, Bennett Lake, 2009.

Origin	Percent of Parties
Local	41%
Whitehorse	56%
Yukon	
Canada	
U.S.	
Other	3%

Visitor Type

Most anglers were day users (Table 4). Only one group stayed at a nearby private campground.

Table 4. Angler visitor type, Bennett Lake, 2009.

User Type	Percent of Parties
Day Users	97%
Camper – Territorial Campground	
Camper – Crown Land	
Camper – Private Campground	3%

Weather

Weather seldom had an adverse effect on fishing activity (Table 5).

Table 5. Sample day weather, Bennett Lake, 2009.

Did Weather Effect Angling?	Percent of Parties
No Possible Adverse Effect	81%
Possible Adverse Effect	13%
Definite Adverse Effect	6%

Catch and Harvest

Lake trout were the most heavily caught and harvested species (Table 6). Arctic grayling were second in terms of numbers caught, but most were released. Fewer northern pike were caught, and their retention rate was low.

Table 6. Angler catch and harvest, Bennett Lake, 2009.

Species	# Caught	# Kept	Retention Rate
Lake trout	128	77	60%
Arctic grayling	108	37	34%
Northern pike	62	14	23%

Estimated angler success rates, calculated over the entire survey as numbers of fish caught per hour of angling effort (CPUE), is presented for all anglers in Table 7.

Table 7. Estimated catch per unit of effort (CPUE; fish/hour), Bennett Lake, 2009.

Species	CPUE
Lake trout	0.13
Arctic grayling	0.11
Northern pike	0.06

Biological Data

Only seven lake trout were sampled for biological data. This sample size is not sufficient to draw meaningful conclusions, and these data are not reported here. All data are housed in the Yukon Department of Environment database.

Comparison with Previous Survey

We previously surveyed the angler harvest on Bennett Lake in 1990. Data on fishing method, access, guided anglers, angler origin, visitor type, and weather were not collected in the 1990 survey, so comparisons between 1990 and 2009 are presented for effort, catch and harvest data only.

Effort

The summer open water angler effort was 23% lower in 2009 than in 1990 (Table 8). With only two data points, we cannot conclude this is a trend; it may represent year to year variation in angler effort.

Table 8. Total estimated angler hours, Bennett Lake, 2009.

	2009	1990
Hours	1,020	1,255

Catch and Harvest

More lake trout were caught in 2009 than in 1990 but the number of lake trout harvested decreased because of a lower retention rate (Table 9). Arctic grayling and northern pike catches were not reported in 1990. Harvest of these species is minimal as only 22 grayling and 14 pike were retained in 2009.

Table 9. Estimated number of fish caught, fish kept and the retention rate, Bennett Lake, 2009.

Species	Retention	2009	1990
Lake trout	Caught	128	99
	Kept	77	99
	Released	51	0
	% Kept	60	100
Northern pike	Caught	62	
	Kept	14	
	Released	48	
	% Kept	23	
Arctic grayling	Caught	108	
	Kept	22	
	Released	86	
	% Kept	20	

Estimated CPUE (number of fish per angler hour) over the entire survey is the statistic that most truly reflects the changes in the fishery because it incorporates effort and catch. Dramatic decreases in CPUE for a particular species could indicate problems in terms of the health or status of the fish species in question. However, relying on CPUE of anglers alone is not recommended – see the section entitled "Invisible Collapse" in the *Status of Yukon Fisheries 2010* (Environment Yukon 2010) – anglers are very good at finding fish even when the population is in decline.

Lake trout CPUE was higher in 2009 (Table 10) and is now close to average for Yukon lakes surveyed to date. The CPUE data for species other that lake trout should be treated with caution; usually these species receive only a small amount of fishing effort, and so these estimates are quite rough.

Table 10. Estimated catch per unit of effort (fish/hour), Bennett Lake, 2009.

Species	2009	1990
Lake trout	0.13	0.08
Arctic grayling	0.11	
Northern pike	0.06	

Fishery Sustainability

We estimate that Bennett Lake could sustain a total annual lake trout harvest of about 535 kilograms OSY (total dissolved solids: 28 mg/L, mean annual air temperature: -1.0 °C, mean depth: 61.9 m; see Methods - *Lake Productivity*). Estimates of sustainable yield are imprecise, so we attempt to minimize risk and maintain fishery quality by using conservative estimates.

Anglers harvested 77 lake trout over the summer (Table 11). Total fish mortality (death) includes the unintentional mortality of any released fish. Catch and release, when done properly, has a minimal impact. Lake trout survival rates range from 93% for lightly handled fish to 76% for deep-hooked fish (YFWMB 1998). We used an average of 85% survival. For the 51 lake trout released, we expect an additional mortality of 8 fish for a total of 85 fish. Based on the average size of harvested fish, the weight of total lake trout mortality in the recreational fishery was 116 kg. This was based on mean weight from 1990 because average weight was not available in 2009; out of 20 lake trout observed harvested only 7 were sampled and only 1 of those had not been gutted before being sampled.

One commercial fishing licence exists on Bennett Lake, with a lake trout quota of 550 kg per year and an average harvest of 300 kg per year. The total commercial lake trout harvest for 2009 was 354 kg.

The Carcross/Tagish First Nation uses Bennett Lake for subsistence fishing and although no data on the harvest have been collected it is believed to be quite small. Ice fishing also occurs on Bennett Lake but harvest has never been formally monitored. Anecdotal information suggests that effort and harvest are minimal.

Harvest estimates for Bennett Lake do not include harvest from the Nares River fishery. Bennett Lake is part of the larger interconnected Southern Lakes system (including Nares River, Nares Lake, Tagish Lake, Six Mile River and Marsh Lake), and lake trout migrate between lakes in this system. The estimated harvest from the Nares River in 2009 was 195 kilograms (Millar et al. 2012); the proportion of this harvest that can be attributed to Bennett Lake is unknown. Because we do not have a good understanding of lake trout migrations in the Southern Lakes, assigning the Nares River harvest to lake trout production from specific lakes is not possible.

Table 11. Estimated summer lake trout harvest by anglers, Bennett Lake, 2009 compared to 1990.

Harvested by Anglers	2009	1990
Lake trout harvested	77	99
Lake trout released	51	0
Catch and release mortality (15%)	8	0
Total harvest and mortality	85	99
Mean lake trout weight (kg)	1.36*	1.36
Total harvest and mortality (kg)	116	135

* Weight based on 1990 mean weight.

Assessing the sustainability of the harvest of lake trout from Bennett Lake is currently difficult; there are many unknowns and sources of error. First, the harvest we estimate is a minimum; it does not include open water harvest outside of the survey period, First Nations subsistence harvest, or harvest from ice fishing. Second, lake trout migrate in and out of Bennett Lake and are harvested elsewhere, such as Nares River. We do not know what proportion of these fish belong to the Bennett Lake stock. As a result, we cannot make robust conclusions about the sustainability of the fishery.

Our minimum harvest estimate of 470 kg (recreational fishery – 116 kg; commercial fishery – 354 kg) in 2009 is nearing the calculated OSY for lake trout. The harvest may exceed Bennett Lake's OSY if additional, unknown harvest levels (such as subsistence and ice fishing harvest) and the contribution of the Nares River harvest combine to exceed ~100 kg. Considering the multiple sources of harvest both known and unknown, there is considerable risk of exceeding sustainable harvest levels in any given year, which could lead to decline in fishing quality or the lake trout population.

We recommend conducting angler harvest surveys as a regular part of monitoring this fishery. We recommend that future surveys also assess in a qualitative, if not quantitative way, any additional harvests. Finally, we recommend conducting studies to determine the migration of lake trout between the Southern Lakes. This information is required to make robust conclusions about the sustainability of the Bennett Lake fishery.

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Appendix 1. Bennett Lake angling regulation changes 1989 to 2009.

Year	Species	Catch limit	Possession limit	Size restrictions
1989/90*			General Regulations	
	Lake trout	3	6	Only one fish over 80 cm
	Arctic grayling	5	10	none
	Northern pike	5	10	none
	Whitefish	5	10	none
1991/92			General Regulations	
	Lake trout	3	6	Only one fish over 65 cm
	Arctic grayling	5	10	Only one fish over 40 cm
	Northern pike	5	10	Only one fish over 75 cm
	Whitefish	5	10	none
2001/2002	Special Management Waters (Waters with Special Regulations)			
	Lake trout	2	2	None between 65 and 100 cm; only one over 100 cm
	Arctic grayling	4	4	None between 40 and 48 cm; only one over 48 cm
	Northern pike	4	4	None between 75 and 105 cm; only one over 105 cm
	Bennett Lake is now a transboundary water; Yukon and B.C. angling licences are valid on all parts of the lake and regulations were mirrored			
2003/2004	*Barbless hooks only*			
2004/2005	Conservation Waters (maximum size limit)			
	Lake trout	2	2	None over 65 cm
	Arctic grayling	4	4	None over 40 cm
	Northern pike	4	4	None over 75 cm
2005/2006	Conservation Waters (slot limit reinstated)			
	Lake trout	2	2	None between 65 and 100 cm; only one over 100 cm
	Arctic grayling	4	4	None between 40 and 48 cm; only one over 48 cm
	Northern pike	4	4	None between 75 and 105 cm; only one over 105 cm
	Whitefish	5	10	none

* Yukon Government obtained responsibility for freshwater fisheries management from the Federal Government in 1989.

Appendix 2. Comparisons between periods, Bennett Lake 2009.

Effort

Mean daily angler effort on weekends was very high in both May/June and July with a substantial drop in August/September (Figure 2.1). Weekday effort was more consistent over the periods, with the highest levels of effort in June and July.

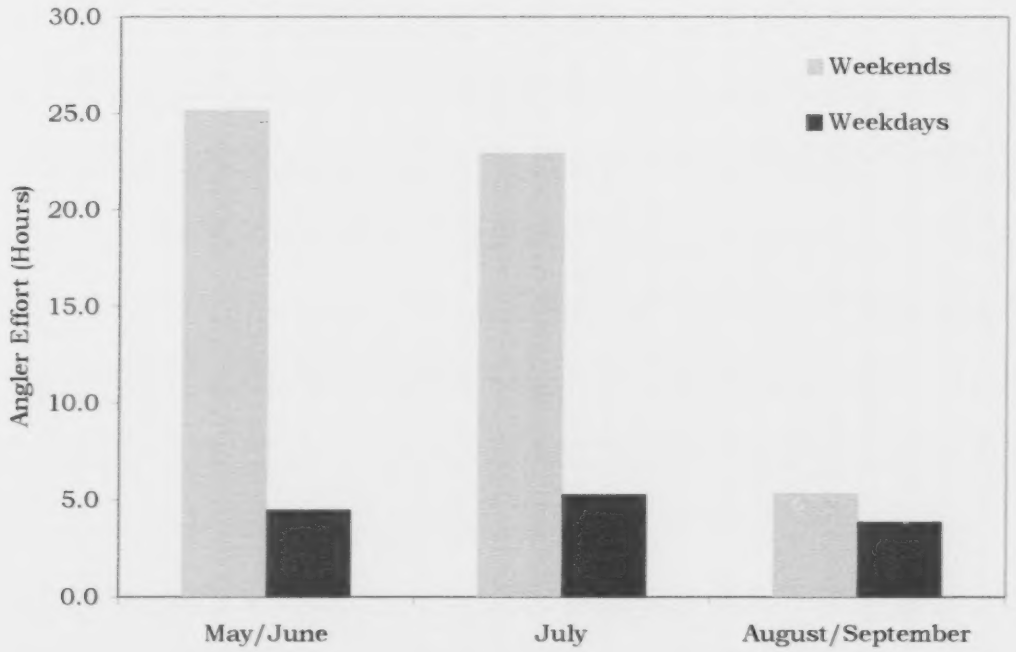

Figure 2.1. Estimated angler effort per day, Bennett Lake, 2009.

Catch

Lake trout CPUE was low over the entire summer. There was minimal angler effort exerted on weekdays in May/June and low success rate on the weekends. Lake trout CPUE picked up slightly in July and remained consistent until the end of the season. There was a minor increase on weekdays in August/September (Table 2.1). Northern pike were only incidentally or infrequently angled for in one period, June weekdays, with low CPUE. Arctic grayling catch rates were low in most periods, but high on June weekdays.

Catch per unit effort patterns for lake trout are somewhat inconsistent with typical Yukon summer patterns. Success is usually high in the spring following ice out and then drops as water temperature warms. Fall increases

are usually related to onset of spawning and cooling water temperatures. These fluctuations are not dramatic on Bennett Lake as CPUE began low, rose to a relatively constant level over the summer, then increased on late summer weekdays (possibly due to the minimal angler effort combined with experienced anglers).

Table 2.1. Estimated catch per unit of effort (fish/ hour) Bennett Lake, 2009, by period.

Period	Lake Trout	Arctic Grayling	Northern Pike
June weekends	0.089		0.193
June weekdays		0.501	
July weekends	0.186	0.149	
July weekdays	0.189	0.189	
August/September weekends	0.187		
August/September weekdays	0.215		